

TITLE:SO2 REMOVAL WITH COAL SCRUBBING

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ABSTRACT

OBJECTIVE

This project is a topic of Identification of Promising Vision 21 Configurations under the UC Innovative Concepts Program, and deals with scrubbing of flue gas to remove SO₂ using a coal as the scrubbing medium. The idea is based on a chemistry in which the combination of SO₂ and oxygen contained in the flue gas has an oxidizing power to leach coal pyrite, and one of the products of the oxidation, ferric iron, can subsequently catalyze the oxidation of incoming SO₂. The major objective is to determine the technical feasibility of this scheme for a commercial process by studying the effects of parametric conditions such as temperature, oxygen concentration and SO₂ concentration on removal efficiency of SO₂.

ACCOMPLISHMENTS TO DATE

A raw coal sample of Pittsburgh No. 8 coal was obtained. This coal sample was crushed, screened, and the minus 28 mesh fraction was floated. The concentrate was dried and screened again to give a size

fraction of 35-65 mesh which has been used in experiments. The chemical analysis of the concentrate shows that it contains 0.13% non-pyritic iron and 1.08% pyritic iron.

Next, an apparatus was set up consisting of gas tanks (nitrogen, oxygen and 1% SO₂), a one-liter reactor and two bubblers connected in series. The reactor is immersed in a thermostated constant-temperature oil bath. The gases, after metered for their flow rates, are combined, introduced into the reactor and bubbled through the coal slurry added to the reactor. SO₂ is dissolved and reacts

with coal pyrite, and the undissolved SO₂ exits from the reactor and is captured in the bubblers. Each bubbler contains 1.5 liters of 1 molar NaOH solution. Two kinds of experiments were conducted to date. First, dissolution of SO₂ was carried out at 21, 57, and 710C. The flow rate was 30 ml/sec. The gas stream had 2000 ppm SO₂ and 10% oxygen. The reactor contains 600 ml deionized water. This solution was stirred at 470-490 rpm. Approximately 15 ml samples were taken from the reactor every 12 or 15 minutes, and analyzed for SO₂ with a back titration method using iodine and sodium thiosulfate solutions. The experiments lasted 60 or 90 minutes. At the end of experiment, an approximately 15 ml sample was taken from each bubbler and analyzed for SO₂ with the same back titration method. The results show that the saturation concentration of SO₂ decreases with increasing temperature. The saturation concentration of SO₂ was 0.0107 molar at 210C; 0.003 molar at 570C; and 0.0017 molar at 710C. The pH of the solution at the end was recorded about 2.5 for all three experiments.

The next two experiments gave a clue as to the technical feasibility of this scheme. This time the experiments were conducted with 60 g of coal added to the 600 ml in the reactor. The temperature was 21 and 590C for each experiment. The flow rate of the stream, the concentrations of SO₂ and oxygen, and the stirring speed were the same as before. Each experiment lasted four hours. Approximately 15 ml samples were taken from the bubblers every one hour and analyzed for SO₂ the same was as before. The recovery of SO₂ was calculated by taking the ratio of number of moles of SO₂ captured in the bubblers to the number of moles of SO₂ entered from the gas tank and then subtracting this ratio from 1.. The number of moles of SO₂ entered was calculated by the ideal gas law. The recovery values at 210C were 64.1% for the first hour; 3.3% during 1-2 hours; -1.1% during 2-3 hours; and -14% during 3-4 hours. The negative recovery probably means that the some SO₂ in the reactor is flushed out to the bubblers while no oxidation of SO₂ takes place in the reactor. The concentration of SO₂ in the reactor may decrease if pH is lowered due to some leaching reaction of pyrite, and then some of the SO₂ will be flushed out of the reactor. As can be seen from the results at 210C, the removal of SO₂ with coal scrubbing is simply not working at this temperature. The recovery of 64.1% during the first hour seems to be due to the adsorption of the gas on the surface of coal.

The experiment at 590C provides promising results unlike the one at 210C. The recovery values were 98.7% for the first hour; 97.4 % during 1-2 hours; 94.3% during 2-3 hours; 94.4% during 3-4 hours. These results are truly encouraging. The recovery seems to decrease as time goes on. This is as expected because as time goes on, sulfate ion concentration increases and thus decreasing Fe³⁺ concentration. The pH of the solution in the reactor after 4 hours decreased to 1.48, which is a strong indication that the leaching reaction of coal pyrite and the combination of SO₂ and O₂ must have taken place. The high values of recovery of SO₂ are obviously due to this leaching reaction. This value was pH 2.18 for the experiment at 210C. However, at this time the sample solutions taken from the reactor are yet to be analyzed for iron.

Significance to fossil energy programs Stack gas desulfurization is an important issue in utilization of coal because combustion of sulfur-containing coal emits toxic SO₂ into the atmosphere. A significant

portion of research money for the recent Clean Coal Technology Program has been spent on research on the stack gas desulfurization process. Although a huge amount of research money has been spent on the process, the backbone of the commercial processes still remains as lime scrubbing which has been used for many years. Lime scrubbing has some weaknesses. One of them is that it produces calcium sulfite which renders huge problems connected with sludge handling and waste disposal. The current project envisions another route for desulfurization, and has a potential to be developed into a feasible commercial process. In this respect, this project can make significant contributions to the fossil energy programs of NETL/DOE.

PLANS FOR COMING YEAR

C to continuously determine the effects of temperature, SO₂, and O₂ on the recovery of SO₂

C to analyze the SO₂ removal in connection with the release of iron from the coal

C to publish a major article in a refereed journal

ARTICLES, PRESENTATIONS, AND STUDENT SUPPORT

Journal Articles

None

Conference Presentations

None

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